Massachusetts Institute of Technology
C. S. Draper Laboratory
Cambridge, Massachusetts

DPC Memo #6-71

TO: Distribution

FROM: R. Larson

DATE: March 9, 1971

SUBJECT: Apollo 15 mission techniques - Descent Meeting 1 March 1971

MIT Attendees: R. Larson, K. Goodwin

1) Descent profile review

MPAD, presented the 25° descent trajectory, primarily as outlined in MSC internal note No. 70-FM-201. The following are a few statements from that document. The Hadley landing area selected for Apollo 15 is in a mountainous region characterized by steep slopes and irregular surface features.

A. STEEP DESCENT TRAJECTORY OBJECTIVES

1. increase margin of clearance above the local surface features
2. provide improved visability perspective of the landing area during approach phase
3. improve fidelity of the landing point designator

B. CLEARANCE

There is a peak in the terrain of 11,000 ft. located 68,000 ft. from the landing site. The 25° traj. clears this by 8,000 ft. (3σ low dispersed traj.) compared to 5,000 ft. for the old 16° traj.

C. VISIBILITY

The 25° traj. altitude at 16,000 ft. range is 2800 ft. greater than the 16° traj. This greater altitude for a given range yields a smaller incidence angle, hence, a better visibility perspective of the landing area.

D. LPD FIDELITY

The 3σ uncertainty in the LPD is estimated to be approximately 2^{o}. From an altitude of 5000 ft. on the 16^{o} traj. the Hadley Rille appears on the LPD scale at approx. 3^{o} from the landing site. On the 25^{o} traj. this is more than 5^{o}. ON the 25^{o} traj. the commander could more readily determine if the PGNS was taking him into the Rille or the landing site.

E. ΔV REQUIREMENTS

The 25^{o} traj. was designed to keep the ΔV expenditure the same as the 16^{o}, however, low gate conditions had to be changed to an H dot of 5 fps and at 200 ft.

F. LANDING SITE REDESIGNATIONS

Both downrange and crossrange redesignations from a 25^{o} traj. require a slight increase in ΔV.

II. MIT (R. Larson) presented the results of the MIT preliminary sim results of the 25^{o} traj. done by Hapet Berberian (See Mission Simulation Memo's #3-71 and another to an undesignated distribution). The salient message that came out of this presentation was that Dave Scott feels that a constant LPD angle is worth therougher pitch variations when you change the altitude weighting functions.

III. Other Notes

A. the landing elipse without Noun 69 updates is 18K ft. along ground track

B. The site is Hadley NORTH VICE SOUTH

2) Abort limits - not looked at yet for the 25^{o} traj. but don't expect any changes

3) Takeover limits - same as 2)

4) LR rules and resonable test bias value

A discussion ensued about the radar problem on Apollo 14. G&C has done some preliminary investigations and analysis and has come up with some proposed fixes. It seems the radar can initially acquire on a side lobe and

then during an approx. 8 sec interval creep to the main lobe. This may result in the radar locking in low scale and never getting to the main lobe and hi scale. Various ways were discussed of correcting this problem. SOME:

1. Cycle CB (as on 14) this causes loss of data for an additional 20 secs.
2. Force hi scale by jury rigging the ANT POS switch. This requires a "simple" hardware change.
3. cycle TEST sw. - it was later learned that this would not have solved the 14 problem.

Dave Scott liked the hardware change because it gives him direct control over the situation. The problem was referred to ASPO.

The resonable test bias is now 500 ft. The Landing Analysis Branch wants to change this to 100 ft. in view that the slope was changed from .125 to .25 (PCR 341). MIT should look at this (DPC #2-71).

5) Timeline undock to T_3

A big power saving campaigne is being done for Apollo 15. The time line was changed to save 22 amper hours from 14. One thing changed was to power up the PGNS about one hour later. This was changed back to where it was to give every body more time to evaluate problems if they existed. The docked IMU fine align has been changed to a P52 docked align using the spiral - cursor option of P52. The "possible" P52 at 101 +30 was made "mandatory" to provide a confidence builder for the GUIDO and LM PGNS to ensure that the compensation values for the last P52 (at 103 +30) are reasonable. MIT has no requirement for the now "mandatory" P52. The COAS CAL and LPD bias determination are done on this P52, however. Timeline Touchdown to Rest. The gravity determination that was performed on Apollo 14 is not in the 15 timeline - covered later.

6) Terrain Model Review

This was not reviewed as such but was discussed during the MIT presentation on the 25^{o} traj. analysis. There is a later terrain profile put out by the

mapping people. I have it. MIT should look at the 25° traj. with the new terrain. (DPC #3-71).

7) Manual descent abort charts

The present 2 angle charts don't work near Hi GATE: you crash. A 3 angle profile is better and will be used.

8) Ullage requirements for abort/stage. - NONE -

9) Attitude requirements for Hi GAIN.

It is required that the vehicle be yawed left 50° for the first 3 MIN of powered descent to yield S-BAND coverage. It was decided to make the initial PDI maneuver to include the 50° yaw and thus at AOS the vehicle will come around at attitude yawed 50°. At PDI +3 the vehicle will be yawed back to the belly band.

10) Landmark time of arrival for crew monitor - ? - I must have been in the bathroom.

11) Gravity measurement requirements

K. Goodwin slides attaches)

12) Other Notes

A. the y dot abort limit will be changed by LAB is presently 90 fps MIT should track this one -

B. What is Noun 69 time limit in answer to what if you don't get RLS_2 update in or the last state vector update in (the SV update max will be like 10K, 20K, 10K; X, Y, Z, E. SCHIESSLER) Conclusions:
a) if RLS_2 or SV is not done by PDI -10 then do N69 prior to P63
b) call P63 no later than PDI -5
c) if N69 is not done by PDI -5 then do back to back N69's at PDI +2 (one for case a)which is data derived from previous a and one from data derived since AOS which assumes a.)

C. What is LPD grid bias limit? (in Apollo 14 the gnd did the update after the crew determination using the 40 degrees mark). For 15 again the gnd will do the update and the crew will carry an

onboard chart - just in case. The lower limit is 1^{o}, in other words, if it is not off by over 1^{o} don't update.

D. 30K - 70K pericyntheon limits - is this good or bad; does the DOI trim maneuver have to shoot for this? The real terrain attitude will dictate the lower limit; ΔV will limit upper limit. LAB to evaluate

E. LR update acceptance limit (on Apollo 14, 3σ was 3800 MAX) LAB to evaluate

F. Crossrange error/perceived by MSFN - compensate with N69 by crew at PDI +5 min. if error is going to take you outside 1 KM (3σ is 4500 ft.) update (this is about 25 fps error). 90 fps y dot is acceptable, that is, radar can take out this much.

G. Downrange error - same

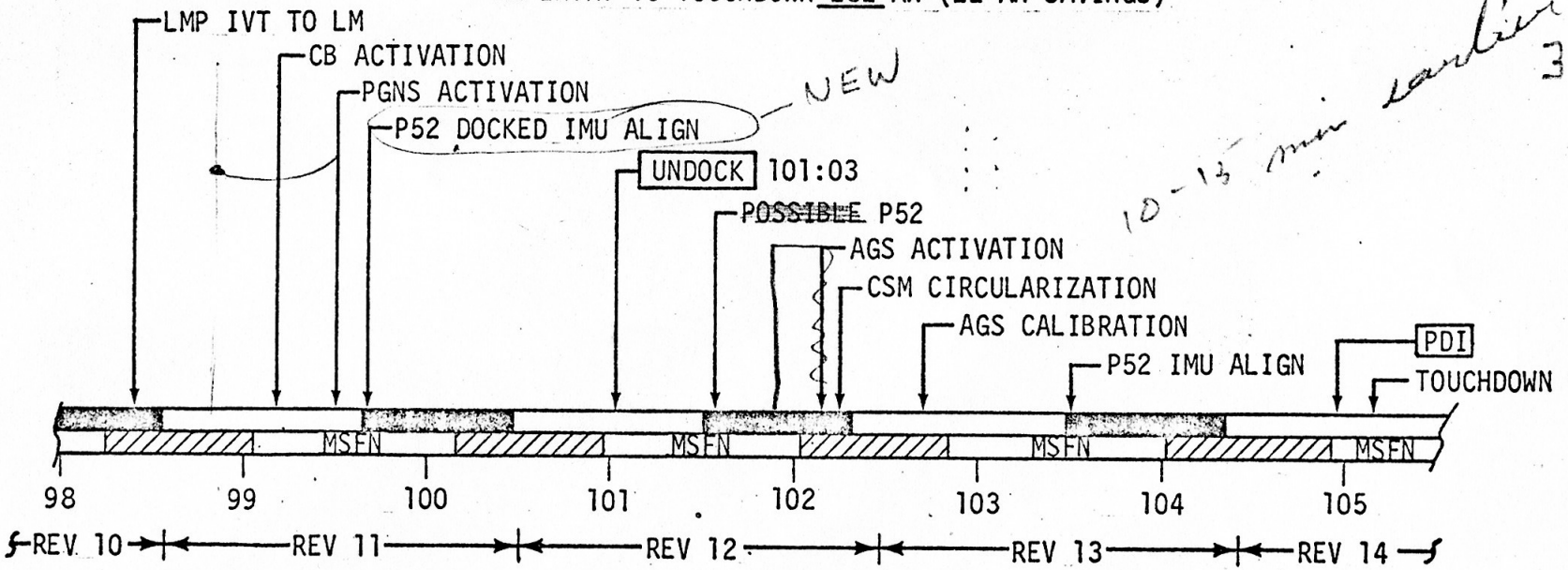
H. Abort limits - 90 fps crosstrack (if you abort on PGNS this gives a 2^{o} plane change), 45 fps downtrack, 35 fps radial.

I. Fred Haise and others are looking at procedures to input N69 values to compensate for system errors via large acceleration sensitive PIPA or gyro bias. This is preliminary but the games are starting. LAB is also working on this - seeing how much y dot you can tolerate without breaking the machine.

I guess to sum it all up - the crew wants to land pretty bad.

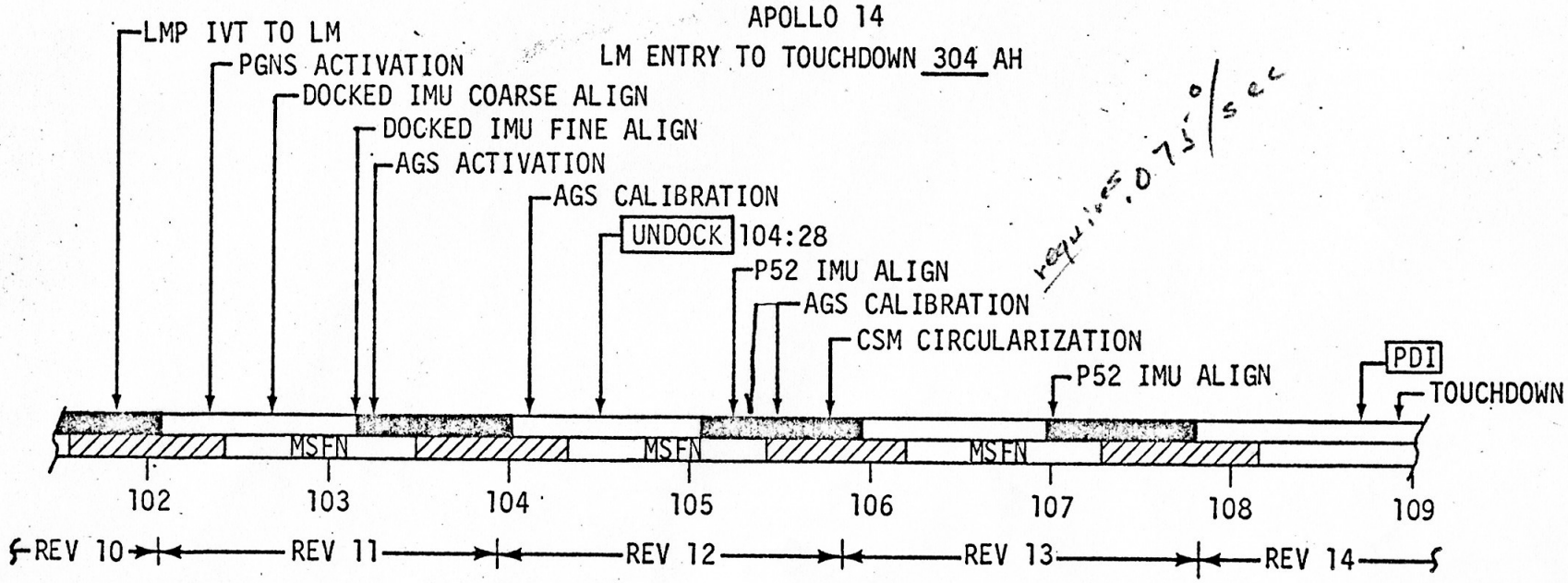
APOLLO 15

LM ENTRY TO TOUCHDOWN 282 AH (22 AH SAVINGS)



APOLLO 14

LM ENTRY TO TOUCHDOWN 304 AH



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(C) TIME LINE CHANGE

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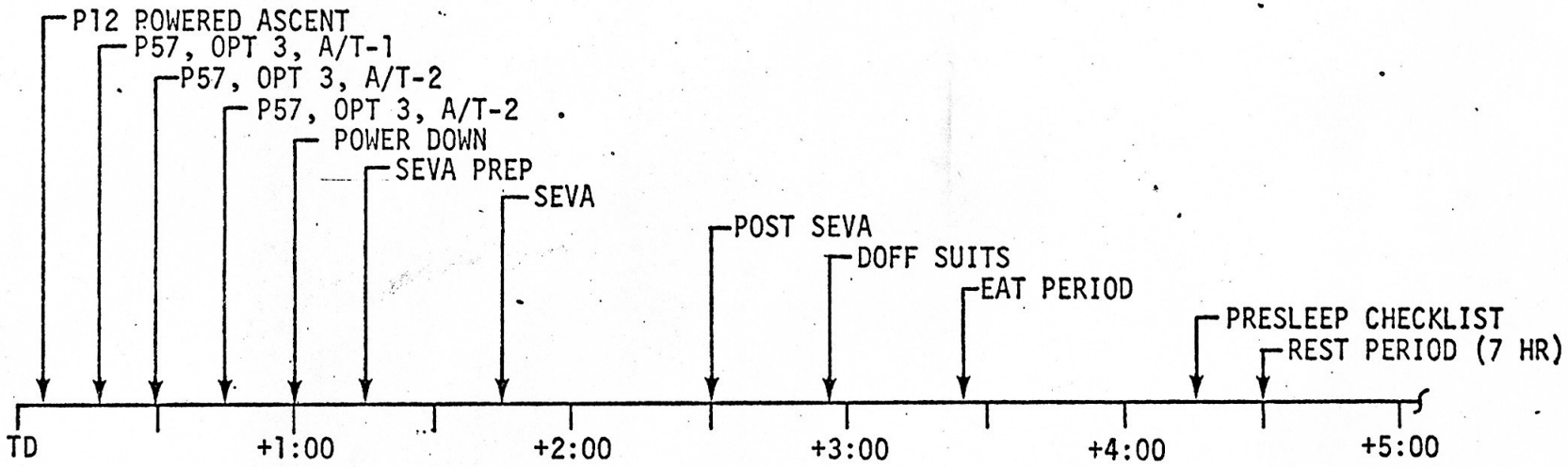
APOLLO 15 SUMMARY TIMELINE
TOUCHDOWN TO REST



FEBRUARY 26, 1971

PURPOSE OF GRAVITY MEASUREMENT

1. TO DEMONSTRATE METHOD FOR USE IN PROVIDING A REFERENCE FOR GRAVIMETER EXPERIMENT (APOLLO 17)

2. SCIENTIFIC PURPOSES
   - A. TO DETERMINE THE RADIUS AT THE LANDING SITE
   - B. PROVIDE ADDITIONAL DATA FOR DETERMINATION OF LUNAR GRAVITY FIELD
   - C. DISCOVER GRAVITY ANOMALIES
   - D. GLOBAL DATA POINTS AT APOLLO LANDING SITES CAN BE USED TO DETERMINE THE SHAPE AND INTERNAL COMPOSITION (CORE?) OF THE MOON.

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